

Syllabus MSNE 416/515

STRUCTURE AND PROPERTIES OF POLYMERS AND SOFT MATTER

Class will regularly meet on M,W, F from 3:00 – 3:50 PM in GRB W211

Perspective

This graduate level course (also available to undergraduates by permission) addresses the fundamental structures and properties of polymers and other forms of soft matter (gels, colloids, nanoparticles, etc) and their many roles as technologically important materials. The electrical, optical, transport, acoustic and mechanical properties are presented with respect to the underlying physics and engineering.

Topics include structures in thin films, effects of nanoscale on properties, processing with 3D printing, light, electrons and ion beams (including interference lithography, directed self assembly of systems of soft materials for metamaterials, actuation and sensing). Examination of the structure of noncrystalline, liquid crystalline and crystalline material states using electron microscopy and X-ray diffraction techniques. Relationships between structure and function in soft matter systems. In class demos.

Learning Goals

- To understand the role of weak interactions (of the order of the thermal energy, kT) on the molecular level arrangements of soft matter.
- To understand the principal types of atomic and molecular structures in noncrystalline (rubbery and glassy), liquid crystalline and crystalline states.
- To be able to relate how the physical properties of soft matter arise from their structures and how various processing techniques can alter the structures and hence the resultant properties. Such understanding provides key insight into structure-processing-properties-performance relationships.
- To be able to apply transmission and scanning electron microscopy as well as X-ray diffraction techniques to elucidate soft matter structures at the atomic to mesoscale.
- To utilize the properties of soft matter in order to be able to design useful engineering materials for a host of technological applications involving multiple desirable functions.
- To learn how to communicate clearly these concepts via oral and written presentations.

Grade Basis

There will be biweekly problem sets that will contain ~ 5-6 questions for students to work and turn in for a grade and an in-class mid-term exam and a final exam during exam period. Students will each pick an individual topic in soft matter to research and present a 3' x 5' poster during the last day of class. Grading will be determined by a combination of problem sets (35%), an in-class midterm exam (25 %), the poster presentation (15%), and the final examination (25%). Extensions on problem sets will be given only in limited circumstances. Homework will normally be due in class on a specific date.

Instructor

Professor Ned Thomas, Materials Science and NanoEngineering.
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Textbook and Resources

Textbook: none required

Useful Reference Textbooks:

Robert J. Young and Peter Lovell, "Introduction to Polymers"

D.F. Evans and H. Wennerstrom, "The Colloidal Domain"

I.M. Hamley, "Introduction to Soft Matter"

Course Website and Online Resources

Course content will be posted on Canvas (<https://canvas.rice.edu/courses/>). This site will be used to make announcements and post handouts, homework assignments, lecture notes, and grades. All students registered for the course should automatically have access to this site. Professor Thomas will regularly check the website and respond to comments and questions posted.

Honor Code Policy

We encourage you to work together on homework problems, but there are also situations in which you must limit collaboration with classmates. Copying is strictly forbidden. Any discussion or collaboration on examinations is also forbidden. Information about the Rice Honor System can be found at <http://honor.rice.edu/>

Accommodations

Any student with a documented disability seeking academic adjustments or accommodations is requested to speak with Professor Thomas during the first two weeks of class. Students with disabilities can also contact Disability Support Services in the Ley Student Center.

Tentative Schedule of Topics

January 8	Course Introduction – Soft Matter
January 10	Molecular Conformations, Sizes and Shapes
January 12	Ideal Chains in Theta Solvents
January 17	Entropies
January 19	Thermodynamics of Mixtures
January 22	Solutions, Blends
January 24	Viscosities of Solutions and Melts
January 26	Characterization I – Scattering of Solutions and Melts
January 29	Glassy State and T _g
January 31	Diffusion and Reptation
February 2	Rubbery State
February 5	Gels, Foams
February 7	Polyelectrolytes
February 12	Liquid Crystalline State – orientational order
February 14	Crystalline State
February 16	Chain Folding Spherulites
February 19	Nucleation and Growth Kinetics
February 21	Characterization II – Diffraction from Ordered Assemblies
February 23	In Class Exam
February 26	Self Organization – Micelles, Ternary Phase Behavior, Colloids
February 28	Block Polymers
March 2	Directed Self Assembly
March 5	Fibers
March 7	The Importance of Defects
March 9	Characterization III – SEM and SVSEM
March 19	Characterization IV – TEM, STEM and CryoTEM
March 21	2D Materials (graphene ++)
March 23	Designing Using Symmetry and Scale
March 26	Processing Methods
March 28	Processing – Property Relationships
March 30	Nanocomposites
April 2	Multifunctionality
April 4	Optical Properties
April 6	Electrical Properties
April 9	Mechanical Properties
April 11	3D Printing and Lithography
April 13	Photonics
April 16	Phononics
April 18	MetaMaterials
April 20	In Class Poster Presentations
Exam Period is April 25 – May 2	